IMPACT OF E-WASTE ON THE OPERATING MODEL OF A CLOSE THE DIGITAL DIVIDE ORGANISATION

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Abstract

This paper aims to illustrate how a general operating model of re-use of electrical and electronic equipment (EEE), and specifically for PCs in developing countries, deals with the challenges and opportunities of increasing e-waste awareness. More specifically, we focus on the role of ICT in the complex societal problem of e-waste in developing countries. The research question we put forward: How can Close the Digital Divide organisations deal with e-waste challenges in a sustainable manner so they can continue to contribute to ICT4D? The paper describes one single organisation and illustrates how the operating model evolved from an open-loop to a closed-loop system i.e. from extending product lifecycles of Information and Communication Technology (ICT) equipment (PCs) to including e-waste recycling in developing countries. This case illustrates how re-use of PCs for developing countries, which are mostly forward supply chains, can be complemented with end-of-life recycling-initiatives to reduce hazardous e-waste. The latter is implemented by the organisation as a global reverse supply chain.

Keywords: Re-use of computers, re-use operating model, recycling e-waste, developing countries, global digital divide, ICT4D, reverse supply chain.

1 Introduction

1.1 The digital divide

An individual's ability to have access to and use computers and the internet plays a crucial role in their education, employment and social inclusion (Broadbent & Papadopoulos, 2013). The literature has provided us with several definitions of the "digital divide" (Hilbert, 2011). Campbell (2001) defines it as a situation in which there is a clearly identified gap in the access and use of ICT platforms. This gap is sometimes described as the difference between the "haves" and the "have-nots" with reference to people with or without access to ICT (Chon, 2001; Cronin, 2002). Furthermore, the digital divide is multi-facetted in nature and can be described as follows (Norris, 2001): the *global divide* refers to the divergence of Internet access between industrialised and developing countries. The *social divide* is the examination of the gap between the information rich and information poor in each country. The *democratic divide* highlights the gap between those who do and do not use digital resources to engage, mobilise and participate in public life. The digital divide is not only a problem of *access* to ICT but also of *usage* of ICT (Sedimo et al., 2011). The *disparity of access* can be seen as a range of differences between along dimensions for hardware, software, modes of Internet connections, … and the *disparity of use* can be seen as a range of differences along dimensions for skills, literacy, mental access and types of usage (van Dijk & Hacker, 2003). Next to providing access to ICT infrastructure such as computers, Internet connections and communication devices (fax, fixed and mobile phones), the digital divide is also influenced by factors such as education, literacy, income, skills, institutional frameworks, competition (OECD, 2004) and human, digital, physical and social relationships (Warschauer, 2001; Hilbert, 2011; Fuchs & Horak, 2008). It is clear that ICT4D initiatives to close the digital divide should go beyond providing access to information and need to be complemented with initiatives and investments ranging from upgrading power grids to upgrading school curriculums (Galperin, 2010). In conclusion, the literature clearly does not provide a uniform definition of the digital divide. It is a complicated notion depending on many factors (James, 2009). Therefore, it is important that we indicate how we will approach it. In this paper we focus on the *global digital divide* as a divergence of both *access to* and *usage of* ICT between industrialised and developing countries.

1.2 ICT4D: Re-use of PCs as a factor to bridge the global digital divide

Based on the literature (Galperin, 2010; Sedimo et al., 2011; James, 2009) it is clear that bridging the digital divide is a very complex, multi-facetted problem with no single solution. Based on an extensive literature review Srinuan & Bohlin (2011) identified several factors that have been studied over the years and proven relevant in bridging the digital divide. They define the following categories: Infrastructure (computers, phones, Internet, …), Socio-Economic Status (Income, GDP, occupation, gender, race, …), Knowledge & Skills (ICT skills, education, literacy, …), Psychological Factors (attitudes, trust, …), Culture (values, beliefs, language, …), Institutional Framework (regulation, policy, …), Price of ICTs, Speed of ICTs, Content provided on ICTs, Quality of Service. Most studies focus on one or a few of these factors.

Re-use of computers as part of electrical and electronic equipment (EEE) is one type of practice often found in literature as a factor in bridging the global digital divide (James, 2001; Kissling et al., 2012; Vallauri, 2009; Williams et al., 2007). Several EEE-types are suitable for re-use (ICT equipment, household appliances, medical equipment, …) yet the re-use of personal computers (PCs) is the most relevant for ICT4D as re-used PCs provide affordable access to information, can play an important role in education, can be used in local businesses and a commercial market has developed for it (Kissling et al., 2012; Williams et al., 2008). High-quality re-used PCs make ICT affordable as the price gap between used and new PCs is far more decisive in developing countries (Williams et al., 2008). There are a number of reasons why the re-use of PCs has grown steadily over the last years. First, the ownership rates of PCs is growing worldwide, both in the developed and developing world

(Kahhat & Williams, 2009). Next, the lifespan (purchase to disposal) of PCs is decreasing significantly. From 6 years between 1985 and 2000 to 5.4 years in 2000 to 3 years in 2007 (Babbitt et al., 2009). Furthermore, the increase of lease-based models, mainly used by organisations, which shorten the first lifespan of PCs, offer a great potential for re-use as the end-of-lease ICT equipment is often still of high quality (Intlekofer et al., 2010). Therefore, end-of-lease PCs are a growing source of re-use PCs. Notice that, even if the lifespan and economic value of a PC in developed countries is around 3 years, these products are not obsolete, broken or useless. Furthermore, as large corporations are giving CSR (Corporate Social Responsibility) and environmental considerations more attention, they start thinking about the end-of-life disposal of their PCs and possible re-use. This can be by selling or donating them their PCs to refurbishment organisations or by including a clause of responsible disposal in their leasing contracts. Combine these three together: there are more PCs that have shorter lifespans in their first use, together with growing awareness on the disposal of these computers and you can see why the re-use of PCs is on the rise.

As discussed by Kissling et al. (2012), re-use of PCs can also be seen as a progressive response to the shortening of product lifespans which is leading to greater pressure on resources. Re-use is a way to extend the use-phase of a product, leading to a resource efficiency increase: lower demand for new products and raw materials to produce them, lower manufacturing impact (according to Williams (2004), the energy needed to manufacture a computer is about 4 times as high as the energy needed to operate it in a normal lifetime), less recycling and waste reduction needed. Figure 1 gives an overview of the product lifecycle value chain and illustrates the lifespan extension re-use cycle.

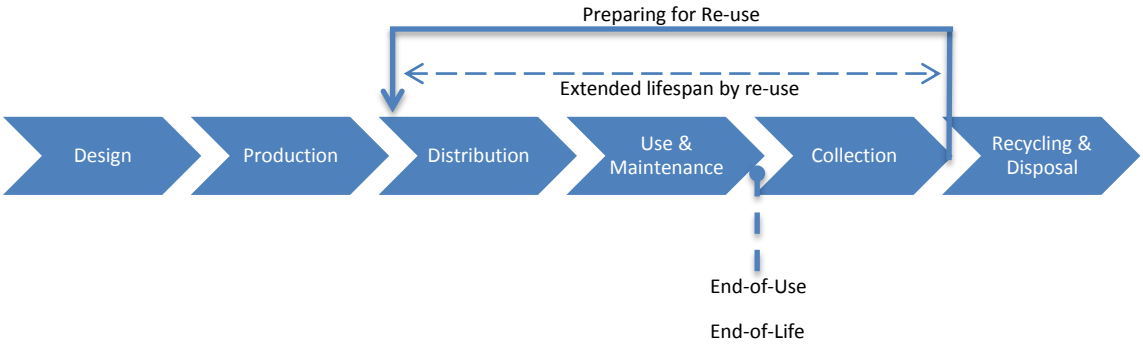

Figure 1. Product lifetime value chain with re-use cycle

As can be seen in Figure 1, both re-use and recycling are 2 possible solutions to the end-of-life problem. Either the PCs are prepared for re-use, extending their lifetime with a second use, or they are recycled and disposed of. From an economic and ecologic point of view, ideally both go hand in hand: re-using the PCs and extending their lifecycle to the maximum after which they can be recycled.

Kissling et al. (2012) define a typology of the most common re-use operating models for EEE. Based on their case-study work they identified four types of re-use operating models: *The Networking Equipment Recovery Model; The IT Asset Management Model; The Close the Digital Divide Model; The Social Enterprise Model*. The first two models are for-profit models whereas the last two are not-for-profit. *The Networking Equipment model* has a clear focus on processing the ICT equipment for the original manufacturers. They extract mostly components and good parts for re-use and the rest is disposed of as e-waste. *The IT Asset Management organisations* specialise in refurbishment and remarketing of desktop and notebook computers for re-sale to distributers and retailers who sell it to individual users. *The Close the Digital Divide model* provides refurbished computers to eligible recipients in developing countries. So, specific about this re-use operating model is that the refurbished PCs get their second life (the extended lifespan by re-use in Figure 1) in developing countries to help bridge *the global digital divide*. Finally, the *Social Enterprises* prepare the EEE for re-use and sell them through retail shops to individual users. The difference with the Digital Divide

model is the intended primary beneficiary. For Close the Digital Divide organisations the main beneficiaries are the schools, communities, individuals in the developing countries who receive the refurbished equipment. For Social Enterprises it is the social benefit such as employment and training gained for people who do the refurbishment in the developed countries that counts. The equipment itself is just sold. In this paper we will focus on the re-use of PCs as described in the Close the Digital Divide Model as this is the model that contributes to ICT4D by supplying refurbished PCs to developing countries.

1.3 Sustainability of close the digital divide model – The e-waste problem

There is growing awareness on the environmental risks associated with end-of-life ICT equipment. The e-waste debate is gaining importance in both the academic and ICT4D practitioners' community, resulting in discouraging or even blocking the import of re-used PCs in several developing countries (Vallauri, 2009). This is a serious problem for the Close the Digital Divide Model. These organisations now have to clearly indicate they are exporting valuable assets to the developing countries, and not e-waste. This means the value of the used PCs has to be higher than the sum of its components recycle value (Kahhat & Williams, 2009). As we discussed in the previous section, re-use and recycle are not or should not be competing end-of-life solutions. In their work, Kahhat & Williams (2009) compared the prices of refurbished computers shipped into Peru with the ideal recycle value of the constituent materials and discovered that in 88% of the times the computer value was higher than the recycle value. This is just one result that shows how the Close the Digital Divide model, focussing on shipping refurbished PCs to developing countries is driven by re-use as opposed to recycling.

There are several environmental concerns regarding e-waste (Ni & Zeng, 2009). First, there is a problem of exposure to hazardous, toxic materials. This is especially the case with informal recycling, where unregulated collectors or "waste pickers" recover end-of-life electronic equipment to extract valuable components. The open burning of copper-bearing wires to remove insulation is one example often found in informal recycling which releases high amounts of toxins, hazardous to the environment and human health. Similar environmental concern arise with landfilling CRT glass. Given the problems with end-of-life disposal of PCs in developing countries, it is important for Close the Digital Divide organisations to think about their reverse supply chain i.e. the series of activities required to retrieve a used product from a user and either dispose of it or reuse it (Williams et al., 2008). Typically, these organisations focus on the reverse supply chain after the first lifetime of a PC i.e. the first re-use cycle (Kissling et al., 2009). However, once the PCs are end-of-life in the developing countries, attention is needed for the second/final reverse supply chain e.g. collecting the end-of-life PCs and recycling them in a way that minimizes the environmental impact in the developing countries (Williams et al., 2008). So, especially for the Close the Digital Divide model it is vital that when the PCs end their second life in the developing countries (go from end-of-use to end-of-life), they are not simply left behind as hazardous e-waste.

So there are ample environmental and health drivers to be concerned about for the end-of-life ICT equipment imported in the developing countries. But there is also a legal reason. The Basel Convention and the WEEE (Waste Electrical and Electronic Equipment) Directive of the European Union impact the movement of e-waste. The Basel Convention controls and minimises the transfer of hazardous waste from developed to developing countries. The EEE directive tries to reduce the amount of hazardous components in EEE and compels producers to take back and recycle EEE in the EU, thus reducing the e-waste stream. This legislation forces Close the Digital Divide organisations to focus on exporting qualitative, well-functioning computers. Furthermore, they should be concerned with the final disposal when their exported computers reach end-of-life.

In this section we highlighted some threats to the sustainability of the Close the Digital Divide Model for re-use of PCs by linking it to the growing e-waste problem. If this ICT4D-model want to remain viable, these organisations will have to make sure that only high-quality PCs are shipped to developing countries and that they contribute to bridging the digital divide by doing more than simply providing

access to infrastructure. Furthermore, once there PCs are end-of-life in the developing countries, they should be properly disposed of. *The research question in this paper is how Close the Digital Divide organisations can deal with these challenges in a sustainable manner so they can continue to contribute to ICT4D.*

2 Research setup

This study can be categorised as exploratory in nature with an inductive design. We start from a single observation which we analyse in-depth in order to derive and extend an operating model. We opted for a single case-study design, which will provide us with rich yet very specific data. Thanks to the work of researchers such as Yin (1984), case studies are accepted as a valid contribution and a legitimate method to the IS field of research (Klein & Myers, 1999). The in-depth case-study is even suggested as "the most appropriate method for conducting empirical research in the interpretive tradition" by Walsham (1995). However, the richness and insights we can generate by limiting ourselves to a single case also limits its generalizability. Therefore, the main contribution of this paper is the insight and richness of the case, which enables us to illustrate and deepen general operating models for re-use of PCs previously defined in the literature (Kissling et al., 2012). However, due to limited generalizability, our results will need to be tested for robustness in future research.

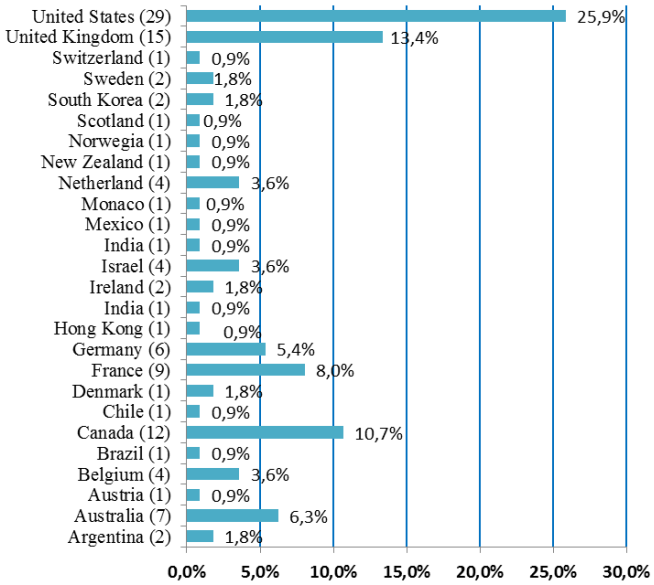

Figure 2. Number of organisations active in re-use of PCs to close the digital divide (covering 26 countries and 107 organisations)

The selection of the case is based on the previous work on operating models for EEE by Kissling et al. (2012). In their study they describe how proper recycling and disposal of end-of-life PCs is the biggest challenge for exporters of used ICT equipment. Figure 2 (based on internal data from the case organisation – Close the Gap) gives a short overview of the number of organisations active in the re-use of PCs to bridge the digital divide (both local and international). This shows USA, UK and Canada have the highest number of organisations active in re-use of PCs for bridging the digital divide. Only half have an international focus, meaning they distribute PCs outside their home country and focus on the *global* digital divide.

Table 1 gives an overview of the Top 5 organisations with international focus based on the number of distributed PCs (data of end 2012). The selected case, Close the Gap (nr 2 with regards to international distribution of re-used PCs for ICT4D), is a Belgian-based Close the Digital Divide organisation, exporting PCs to developing countries with a specific focus on e-waste and recycling end-of-life PCs.

Ranking	Top 5 Close the Global Digital Divide Organisations
1	Computer Aid International (United Kingdom): 201.437 PCs have been distributed.
2	**Close the Gap (Belgium): 72.570 PCs have been distributed.**
3	Computers 4 Africa/Digital Pipeline (UK): 36.000 PCs have been distributed.
4	Camara Education Limited (Ireland): 30.000 PCs have been distributed.
5	InterConnection (United States): 30.000 PCs have been distributed.

Table 1. Top 5 of the internationally oriented organisations – based on PCs distributed

This is the only Belgian organisation with this operating model, and one of the few European organisations involved in both exporting PCs and handling the resulting e-waste. Figure 3 gives an overview of the methodological procedure we followed to derive our results and conclusions.

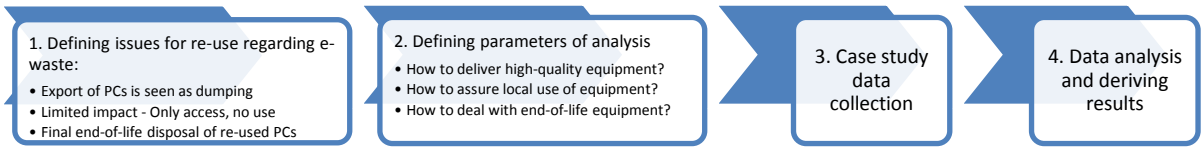

Figure 3. Methodological procedure

In section 1 of this paper we addressed step 1 and discussed the issues for re-use models that aim to bridge the global digital divide. In step 2 we derived our parameters of analysis that will enable us to identify the strengths in the operating model to deal with the issues of step 1. Step 3 - data collection is based on different data sources: internal and public documents, personal interviews, direct observations, participant observation in the field and physical artefacts (mainly photographs & video material). As one of the researchers has direct involvement with the organisation we applied a division of responsibilities for the research. The involved researcher was excluded from data processing or writing the research report. He was mainly involved in pointing out possible data sources and providing insight into the context of the research project. In step 4 we analysed all our data and made a list of possible actions we identified that could contribute to the questions in step 2. An expert panel composed of 2 professors and 2 ICT4D practitioners very familiar with the different operating models of Close the Digital Divide organisations validated the list of actions. Only the validated actions are discussed in the sections that follow.

3 In-depth case discussion

3.1 Introduction to Close the Gap

Close the Gap is an organisation that describes itself as follows: *Close the Gap is an international not-for-profit organisation, recognised as a United Nations DPI NGO, that is helping to bridge this digital divide by offering high-quality cost-efficient used ICT equipment to projects in developing countries. Socio-educational programmes linked to schools, hospitals and other projects that focus on improving educational and information facilities can all ask for support from Close the Gap. The objective is to assist in improving local knowledge and putting local talent to use by offering cost-efficient ICT-solutions to projects in developing countries. The organisation collects computers from donors, arranges for the hard disks to be cleaned, and the hardware to be checked and configured according to the requirements of the end-users. The computers are then shipped to their destination by sea or air, where a support and maintenance programme ensures good usage and sustainability of the computers.*

3.2 Description of the operating model

Like most Digital Divide organisations, Close The Gap (CTG) has a focus on desktop and laptop computer systems. They made a clear choice for PCs and ICT related products (printers, spare parts,

servers, monitors) but do not include other electronic equipment or large household appliances. Figure 4 gives an overview of the operating model. In the sections that follow we describe the different components of this model.

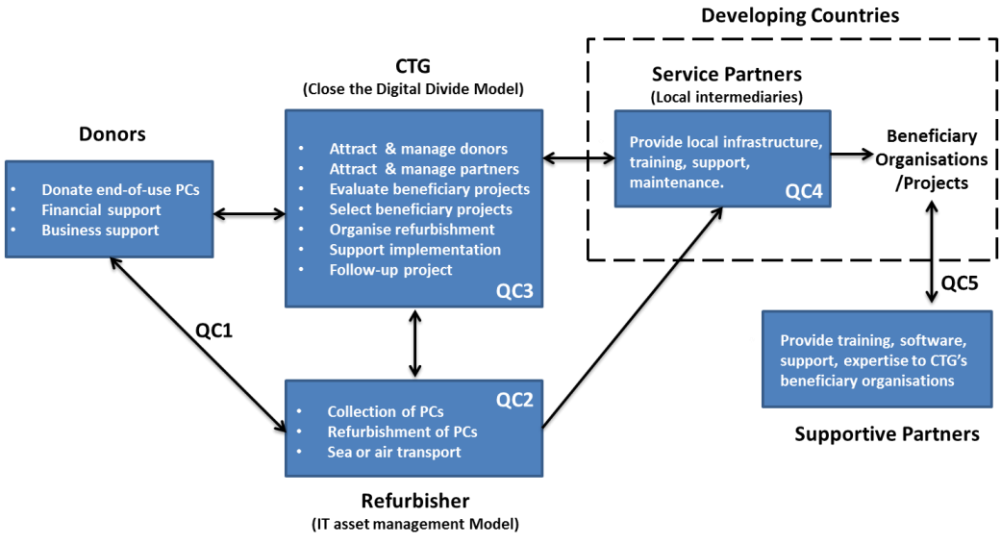

Figure 4. Close The Gap operating model

3.2.1 Donors

Donors are commercial and public organisations that provide financial support or business support but mainly donate high quality (top branded PCs), uniform and a sizeable amount (minimum 20 PCs including monitors) of PCs. CTG does not accept PC donations from individual users as a lack of uniformity in PCs increases difficulties of installing, maintaining and finding replacement parts in the developing countries. CTG has the following minimum requirements for the donated PCs: Pentium IV 2.4GHz computers, 15″ TFT flat screen monitors, laser printers and Pentium Centrino 1.6 GHz laptops. By working with donation requirements CTG is able to increase the quality, reduce the price and reduce the maintenance cost of the PCs they deliver to developing countries. Furthermore, these strict donation requirements are a first important step in reducing the e-waste problem in developing countries. By keeping the quality of exported PCs high, the re-use lifespan is increased and PCs degrade more slowly towards e-waste. As discussed by Kahhat & Williams (2009), the value of exported PCs has to be considerably higher than the recycle value of its components, otherwise organisations are exporting (near) e-waste to developing countries. With over 16 000 computer assets delivered in 2011 and more than 70 000 over the past 7 years (and this is only one organisation), this is a considerable source of either valuable PCs or hazardous (near) e-waste. The donation requirements quality check is a first important differentiator between a valuable ICT4D initiative or dumping obsolete e-waste from the developed world in the developing countries.

3.2.2 Refurbisher

Refurbishers are the IT Asset Management organisations we described in the section of re-use operating models. CTG has completely outsourced all refurbishment operations to a professional IT Asset Management partner organisation. The refurbisher collects all ICT equipment from the donor organisation. Next, the refurbishing procedure starts to ensure that only high-quality PCs get shipped to the developing countries. The procedure consists of 5 steps: 1) Check-in & registration: PCs get unique barcode for traceability – 2) Reconditioning: testing, cleaning, data-wiping, upgrading of PCs – 3) Final inspection of PCs & adding new keyboard, mouse & headphones- 4) Transport: packaging for sea or air transport – 5) Reporting: donors receive status report on donated PCs & data-wipe

certificates. The refurbishment phase is a second quality check to make sure only high-quality, valuable PCs are shipped to developing countries.

3.2.3 CTG project team

The core activities of the CTG project team is to source PCs from donors and to identify & select eligible recipients in the developing countries. Activities include: attracting and managing donor organisations and partners, organising and follow-up of refurbishment, evaluating and selecting beneficiary projects, supporting local implementation & follow-up. CTG operates worldwide in developing countries but the core of its beneficiary projects is located in Sub-Saharan Africa. CTG evaluates and selects beneficiary projects that are focussed on empowering the individual and his/her community. The projects are situated in the following sectors: education, health, environment, microfinance, research, social, culture, good governance. From a financial perspective, CTG does not cover all refurbishing and shipment costs. As the goal is to establish beneficiary partnerships, service partners or beneficiaries in the South are asked to contribute financially to (part of) these costs. CTG may decide to co-finance with third-party funds or its own allocated funds. Many of CTGs projects are based on this *co-ownership model* and evaluation of this model indicates that it adds a sense of ownership, responsibility and proudness with the beneficiaries. This leads to more sustainable projects and extends the re-use lifetime even further as beneficiaries have more focus on maintenance and long-term use of the PCs they buy. The word "buy" is important in this respect as beneficiaries no longer see these projects as charity but more as a business deal. Similarly, beneficiaries have to make a case for their projects before they are able to receive a donation of PCs from CTG. In their application they have to demonstrate sustainability of their proposal: is the necessary local infrastructure in place, how will training be provided, how will support and maintenance be handled, … Sustainability is a prerequisite in CTGs operating model. In order to ensure this sustainability, beneficiaries can benefit from CTGs service and support partners.

3.2.4 Service & supporting partners

Service partners are local partners in the developing countries who act as intermediaries between CTG and the beneficiaries. They know and understand the local problems and challenges, have local project management expertise and ensure the sustainability of the projects. CTG establishes client-supplier relationships with the service organisations thus professionalising the relationship. Service partners are an important aspect of quality assurance as they are responsible for preparation of the local infrastructure (making sure that donated PCs have a secure location with all necessary utilities like electricity, internet if available, …), distribution and transport of PCs to the beneficiaries, installation and maintenance of ICT equipment, training project managers/teachers/users and finally, taking back the ICT equipment when it reaches end-of-life. *Supporting partners* are usually north-based organisations that provide training, support, software, expertise to the beneficiaries in the South. They complement CTGs hardware donations with content, applications or specific know-how that adds value to the project. Examples are e-learning software for children, training programs on use of ICT, know-how on how to use PCs in entrepreneurial ventures, content/information on HIV-prevention, smart energy solutions to provide electricity in remote areas.

3.2.5 Ensuring sustainable impact

In this section we build the first lessons learned on the social impact from analysing and discussing CTGs operating model. Babbitt et al. (2011) argue how re-use of end-of-first-life computers can have a positive social impact. Lower prices of refurbished computers make ICT an accessible asset in low income communities in developing countries. Reducing the digital divide has a positive impact on education settings (Baskaran & Muchie, 2006), health & prevention initiatives but also on entrepreneurial activity of small and medium sized enterprises (SMEs) as they see the refurbished computers as a way to redefine their businesses (Kahhat & Williams, 2009). Additionally, there are clear economic benefits (growing economic activity and employment of people involved) in these

projects. So there is a clear *economic & social benefit* associated with these activities. Furthermore, a second important benefit created by these organisations is the *product lifespan extension.* As stated by Williams (2004) much of the environmental burden of computers is driven by the high energy intensive manufacturing process. Re-use prolongs the computer lifespan thus reducing the negative impact on the environment. For each re-used computer we avoid or at least postpone creating a new one, requiring less energy and less resources. Finally, we identified a clear focus on *minimising the end-of-life risk* of the computers by building in several quality checks in the operating model. In figure 4 we indicated the quality checks as QC1-QC5. These quality checks are put in place to prolong the second life of PCs in developing countries as long as possible: QC1 - Donation requirements increase re-use lifespan leading to slower degradation towards e-waste. QC2 - Refurbishment and quality assurance of PCs shipped to the South. QC3 - Empowerment and ownership creation over donated PCs. QC4 - Leveraging local social entrepreneurship to surround the projects with a support organisation. QC5 – Increasing the usefulness and value of the PCs by complementing them with relevant, value-adding information & services.

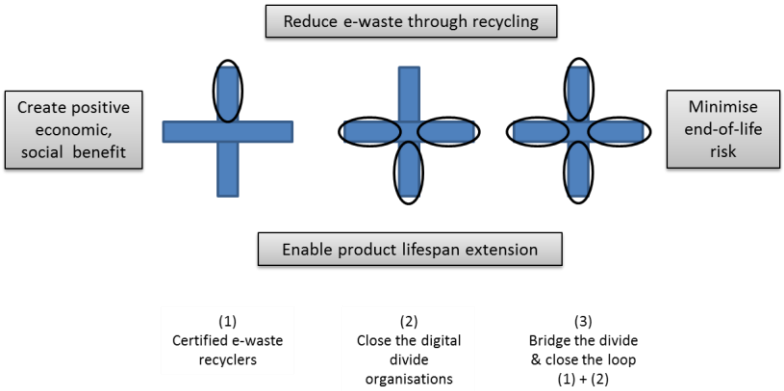

Figure 5. Illustration of the different types of impact of the operating model (Adapted from Babbitt et al. (2011))

Figure 5 illustrates 3 types of impact targeted for this Close the Digital Divide model we just discussed. The fourth one, reducing e-waste through recycling, is what we focus on next.

4 Closing the loop

As discussed in the previous section, maximising the re-use lifespan of PCs has a positive environmental impact as it reduces the need for production of new computers, which means less use of scarce resources, energy and less waste. However, at a certain moment in time the re-used PCs reach their end-of-life in the developing countries. At that moment the risk is high that the computer material will improperly or informally be disposed of, transforming it into hazardous e-waste. Informal recycling takes different forms: landfilling, unprotected disassembly, open incineration and acid washing are the most common. With these techniques a lot of heavy metals and toxic fumes are released leading to serious pollution and health risks: respiratory diseases, poisoning, kidney stones and miscarriage (Zhou & Xu, 2012). Dealing with end-of-life equipment is an important factor of the sustainability of the Close the Digital Divide operating model. Figure 6 gives an overview how Close the Gap expanded its operating model in 2010 with their e-waste recycle initiative called Worldloop.

First of all, CTG and its refurbisher (Flection international) fully comply with the legislation discussed in section 1.3 (WEEE, Basel convention). If equipment tests fail and the computers are of too low quality for re-use, they will be immediately disassembled and the waste disposed of and handled by European-approved downstream handlers. Given their 0% landfill policy CTG does not ship malfunctioning equipment or hazardous e-waste to their projects in the developing countries. However, this does not solve the proper recycling problem of end-of-life ICT equipment of their projects. Since CTG wants its projects to be e-waste neutral and since they faced the problem that the

necessary take-back systems and specialised processing infrastructure are currently almost non-existing in the countries they were active in, they started their own e-waste solution. *Worldloop is a separate non-profit organisation committed to extending the positive impact of ICT projects in developing countries by offsetting the negative environmental impact of its hardware. Worldloop facilitates the creation of accessible and formal e-waste recycling solutions in developing countries.*

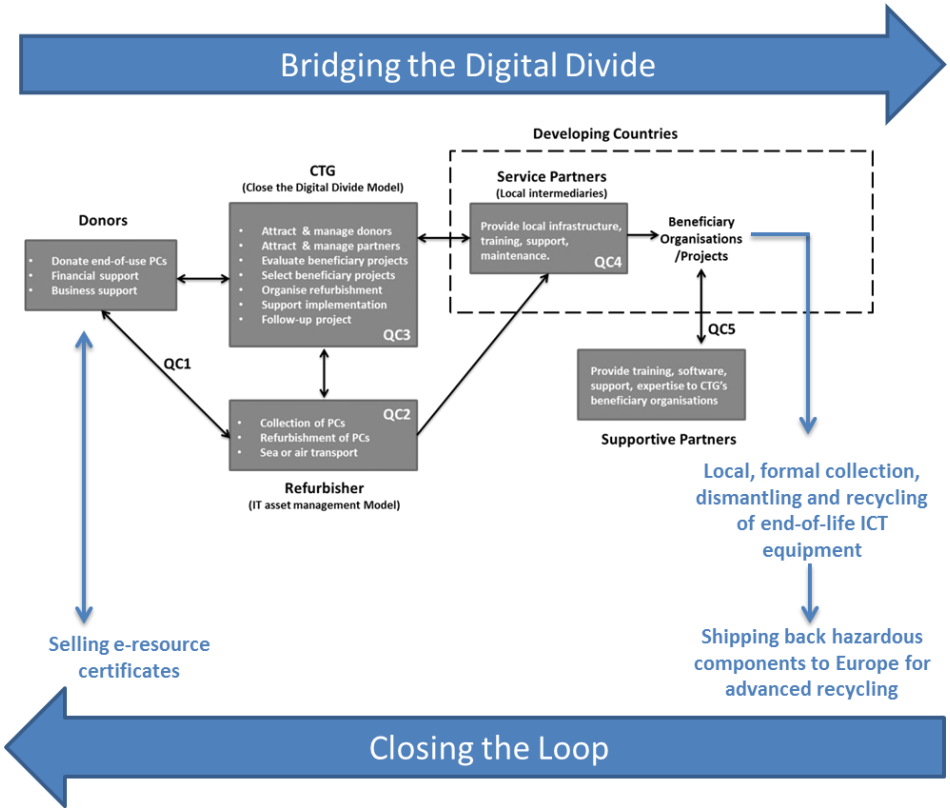

Figure 6. Closing the loop with e-waste recycling

Worldloop connects with local partners in the South who organise and execute the reverse-logistics of end-of-life computers. The PCs are collected and transported to a new recycling centre. In 2011 Worldloop created the WEEE (Waste for Electrical and Electronic Equipment) centre for the East-African Community. The centre was inaugurated by Mrs. Neelie Kroes (Vice-President European Commission), illustrating how regulators welcome this approach. The first Worldloop facility for e-waste recycling is situated in Nairobi (Kenya) and specializes in the end-of-life management of ICT equipment. The centre is a local solution that dismantles and recycles e-waste but in a formal, environmentally safe way, in secure conditions and using specialised equipment and protection. Hazardous components that cannot be recycled locally (mainly CRT glass and PCBs (Printed Circuit Boards)) are shipped back to Europa for advanced recycling. Up till today Worldloop is active in 6 countries, 10 000 computer assets have been collected and recycled in Kenya (132 tons), 12 tons of PCBs and 32 tons of CRT glass have been shipped back to Europe. The organisation is funded through donations and e-Resource certificates. An e-Resource certificate can be purchased by organisations, mainly as part of their CSR (Corporate Social Responsibility) policy. The certificates are used to fund the local operation costs of the recycling centre and to ensure proper international recycling of complex, hazardous components. Today, most e-Resource certificates are bought by the Close the Gap donor organisations to offset the possible negative impact on e-waste: 1 e-Resource certificate per re-used PC shipped to developing countries. This is how this reverse supply chain for end-of-life computers (which is the network of activities involved in the re-use, recycling and final disposal of products and their associated components and materials) is funded. The certificates are also a symbolic way to "close the loop" (figure 6) as in the first step of the operating model donors of end-of-use PCs

buy these certificates to make sure they are properly disposed of years later. At the beginning of the cycle donors already take on the responsibility for the end of the cycle. The impact of this model can be summarised as follows: 1) Supports import of high quality ICT equipment by offsetting the possible negative environmental impact at end-of-life. Makes it a sustainable solution. 2) Disintermediation of informal recyclers from the reverse supply chain – Positive environmental and health impact. 3) Employment creation. 4) Awareness and ownership creation of this problem with organisations in the North. Depending on how it is implemented, a take-back/recycling system can either stimulate or inhibit re-use, which ultimately determines the economic, social and environmental impact. As discussed by Williams et al. (2008) there is insufficient evidence to conclude that recycling as a stand-alone activity (figure 5 - (1)) generates sufficient benefits in dealing with computer e-waste. On the other hand, Close the Digital Divide organisations (figure 5 - (2)) cannot ignore their possible impact on e-waste. In this paper we argued that the real value is to be found in the combination of substantial re-use of computers and formal recycling after the final end-of-life. This maximises economic and social benefits of this ICT4D initiative while minimising the possible environmental impact.

5 Conclusions and future research

In this paper we contributed to the research question on how Close the Digital Divide organisations can deal with e-waste challenges in a sustainable manner so they can contribute to ICT4D. We did this by an in-depth study of the operating model of an organisation who started as exporter of PCs to development projects in the South but complemented their model with reverse supply chain activities to reduce possible e-waste impact. Our study highlight a number of management practices which increase the quality of the exported PCs and possibly prolongs the re-use phase in the developing countries: working with donation requirements, strict quality refurbishment, empowerment and ownership creation over the PCs, embedding projects in a local support organisation and complementing the PCs with value-adding information & services. The local impact of these PCs can contribute in closing the global digital divide was already discussed in the literature: affordable access to ICT equipment, different and better education, health & prevention, economic benefits such as job creation and productivity increases in small businesses. This positive societal impact which not only the *acces* but also the *use* of PCs provide should not be abandoned due to the negative environmental and health impact of e-waste. We illustrated how the Close the Digital Divide operating model could and should be complemented with e-waste recycling model to close the loop. For this single in-depth case, combining both models offers the best economic, social and environmental outcome of this ICT4D initiative. We gained insight in the use of management practices and instruments on the re-use of PCs to close the global digital divide can deal with e-waste issues. The results of our case study have of course limited generalizability as it is just one single observation. Future studies could focus on multiple organisations, confirming or denying the observations we put forward. Furthermore, there is a strong need for research from the accepting organisations/beneficiaries point of view: what are the local, social implications of an ICT4D project combined with e-waste focus in a specific community? Which specific skills or capabilities do ICT equipment improve and how are they leveraged in the local community?

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